Argonne NATIONAL LABORATORY | Feature

Argonne battery technology helps power Chevy Volt

This month, thousands of new Chevy Volt owners will begin the real road tests of the first mass-produced plug-in hybrid electric car. While much of the car's engineering is unique, consumers may be unaware that some of its most extraordinary technology is inside the nearly 400-lb. battery that powers the vehicle in electric mode.

The battery's chemistry is based in part on a revolutionary breakthrough pioneered by scientists at the U.S. Department of Energy's Argonne National Laboratory. The new development helps the Volt's battery—a lithium-ion design similar to those in your cell phone or laptop—last longer, run more safely and perform better than batteries currently on the market.

"To me this cuts right to the heart of green energy," said Jeff Chamberlain, who heads Argonne's battery research and development. "This battery technology is a step towards energy independence for the U.S.; it helps create jobs; and it can have a positive impact on the environment."

The story begins in the late 1990s, when the DOE's Office of Basic Energy Sciences funded an intensive study of lithium-ion batteries.

"Existing materials weren't good enough for a high-range vehicle," explained Michael Thackeray, an Argonne Distinguished Fellow who is one of the holders of the original patent. "The Argonne materials take a big step forward in extending the range for an electric vehicle." In order to improve the design, scientists had to know how batteries worked at the atomic level.

"What we really needed to do was understand the molecular structure of the material," said Argonne chemist Chris Johnson.

At its most basic level, a lithium battery is composed of a negatively charged anode and a positively charged cathode. Between them is a thin membrane that allows only tiny, positively charged lithium ions to pass through. When a battery is fully charged, all of the lithium ions are contained in the anode. When you unplug the battery from the charger and begin to use it, the lithium ions flow from the anode through the membrane to react with the cathode—creating an electrical current.

A battery replica (left) is positioned near a 2011 Chevrolet Volt electric vehicle. Image courtesy General Motors.

The team wanted to improve the cathode, the positively charged material. They began by using incredibly intense X-rays from Argonne's Advanced Photon Source synchrotron to monitor and understand reactions that occur in lithium

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batteries—in real time. Next, they set out to modify and optimize the cathode materials. Using new synthesis methods, they created lithium- and manganese-rich materials that proved remarkably more stable than existing designs.

Because manganese-rich cathodes are more stable than those used in today's batteries, the new batteries are safer and less likely to overheat. Manganese is cheap, so the battery will cost less to manufacture. The researchers also upped the upper charging voltage limit to 4.6 volts—higher than the usual operating voltage—and saw a tremendous jump in the battery's energy capacity.

The Argonne battery design became, in a radical leap forward, cheaper, safer, and longer-lasting.

"To me, that's exceptional," Chamberlain said. "New advances often sacrifice cost or safety for performance; it's a rare breakthrough that improves all three."

Batteries for electric and plug-in hybrid cars are much larger—and thus far more expensive—than laptop batteries, and they make up a large percentage of the car's price. Lowering the cost of the battery will lower the cost of all-electric and hybrid cars, according to Khalil Amine, an Argonne senior materials scientist, and subsequent improvements will improve battery performance even further.

"Based on our data, the next generation of batteries will last twice as long as current models," Amine said.

The team—especially the co-holders of the original patent: Thackeray, Johnson, Amine, Jaekook Kim and Sun-Ho Kang—is happy to see the technology make its way from the laboratory to the road.

"I would love to point to a car on the street and tell my son, 'This car has our invention in it!'" Amine said.

"Seeing homegrown innovations going into a large-scale production like the Volt—that's really exciting and good for America," Johnson added. "It's really the ultimate goal for a researcher."

Furthermore, Chamberlain said that the new battery technology pioneered by the lab can boost American manufacturing and create new jobs.

"Batteries are a large, heavy component of electric and hybrid cars, and so it's best to manufacture them near the factory where the cars are assembled," Chamberlain explained. "This means cars assembled in U.S. factories will also need battery factories nearby—creating more American jobs."

A total of $1.5 billion in stimulus grants went to several companies last year—including A123 Systems, Johnson Controls and Compact Power, an LG-Chem subsidiary—to build battery plants in the U.S. (A full list of the grants is available online.)

Chamberlain, who worked in private industry for 13 years before joining Argonne in 2006, says the national laboratories play a crucial role in developing these kinds of breakthrough technologies. "The labs perform basic research," he said. "In the U.S., businesses tend to invest in research that will pay off in the short term; in this field of research, the national laboratories are filling a gap by conducting the essential research that will change the game ten to 20 years down the road."

When companies show interest in the technology, he said, the labs collaborate with them to help adopt the method for large-scale production.

"Seeing this play out is absolutely gratifying," Chamberlain said. "We're developing technology that I'm highly confident will help make plug-in hybrid cars more economic. The work at Argonne ends up in the hands of taxpayers who paid for research. This is a fulcrum, a key component to moving away from fossil fuels."

The technology remains available for licensing.

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By Louise Lerner.

PRESS CONTACT ▸ Angela Hardin | 630-252-5501 | media@anl.gov | Media Relations | www.anl.gov